Automated production of national topographic map in IGN-Spain

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Abstract. This paper reports the development of a tool for automated production of the National Topographic Map of Spain at scale of 1:25k (MTN25) from a continuous topographic database, the National Topographic Database (BTN25), i.e., from a 1:25k Oracle database. To meet this goal, a unique tool that integrates all the processes was required. The FME environment was chosen as an integrating tool since there is a good knowledge of this software by IGN cartographers. Furthermore, it allows us to perform all operations needed (Extract-Transform-Load). The quality of this process is guaranteed by reviewing the results with the controls and standards used in the current production process.

Keywords: automated cartography, automated production, cartographic edition, symbolization, generalization

1. Introduction

The IGN is the national mapping agency of Spain responsible for the production, maintenance and updating of, among others, the map series 1: 25k. This cartographic series consists of more than 4100 sheets of hard copy maps, covering an area of 5’ in latitude by 10’ in longitude (about 12 500 ha).

The need to speed up production to keep the information updated, upcoming current high quality standards, has forced to IGN, since mid-2013, to develop an automated tool. This development replaces the set of manual, semi-automated and automated techniques currently used in MTN25 production, according to the technological changes carried out in the cartographic production workflows of our agency in recent years (García et al, 2013).

Through this new tool, a unique FME process which is divided into different sequential threads for the different topics, a CAD-file is obtained. This file is conceived to be the final product (downloads, Webmap viewers and Web services) or to be a hard copy map through a manual mini-edition. Nowadays, the source is an Oracle database (BTN25) and the output is a MicroStation DGN-file, but it could be another one (GeoMedia, Adobe Illustrator or ArcGIS files).

In this way, it is possible to reduce the production time, sacrificing aesthetic quality of the current map. This goal fulfils the users requirements, who prefer a more updated product, albeit at the expense of a small loss this final aesthetic quality.

2. Methodology

The traditional semi-automated process used to obtain MTN25 starts with the transformation of BTN25 features using generalization and symbolization tools. Then, the administrative boundaries and toponyms are incorporated and land use coverage (SIOSE) is also generated. After incorporating all this elements, a laborious stage of editing and generalizing elements and text is carried out to remove mapping conflicts. In the next stage, the sheet frame, and legend are placed. Finally, an automated and visual quality control is performed.

In Figure 1 the differences between the traditional semi-automated and the automated process are showed. The semi-automated phase of the traditional process **BTN to MTN** is replaced for an automated phase that includes other phases of the traditional process (squares in blue color) meanwhile other phases, such as the **reference system ED50 to ETRS89 transformations,** have disappeared from the process**.** Finally, in the workflow generating a printer map, the high laborious phases as **manual edition** and **visual control** are replaced by mini-edition and visual control phases. In the last phase of the new workflow it is no longer necessary to upload the maps for downloads, viewers and web services, so, the product availability is even faster.

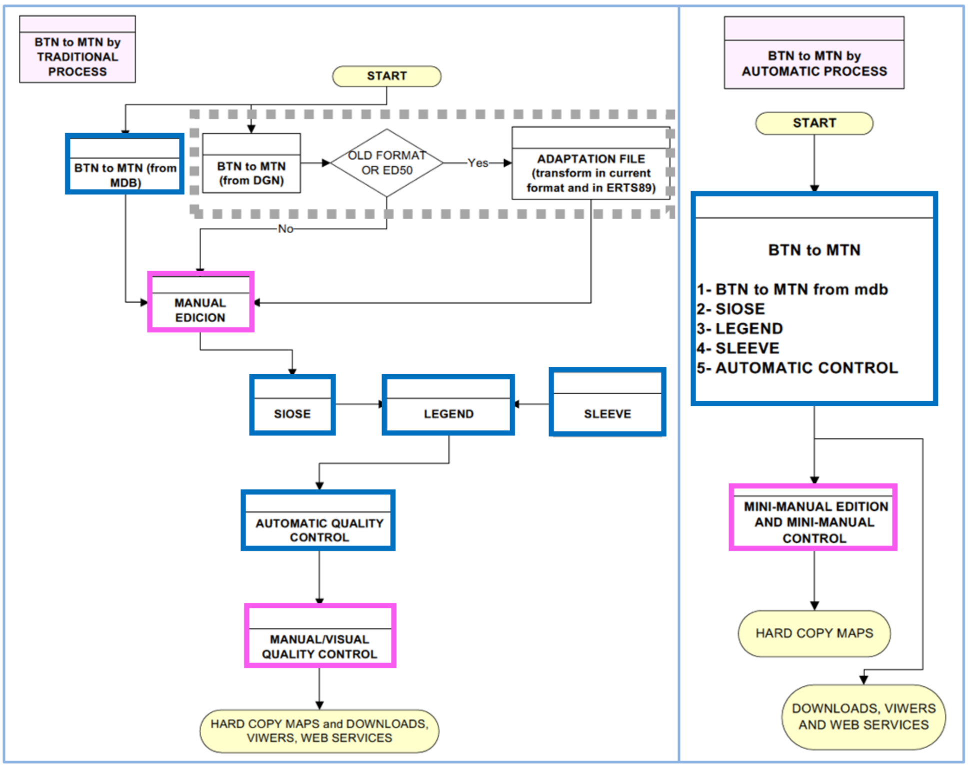

Figure 1: Differences between traditional and automated process workflow.

The automated process, due to the characteristics of the map series MTN-25, covering an area of more than 500 000 km^2, requires some careful considerations about the so different geometric situations and the wide range of symbology involved. In this way, we have envisaged the largest number of combinations of possible situations that may arise and solved each of these situations with different threads. This implies to consider the scheme of the general strategy and also the specific threads that are needed in the process.

2.1. General strategy

As data models for MTN25 and BTN25 are currently undergoing various changes, implying changes in the medium term in the automated process, the overall strategy has been the design of a tool easy to learn and easy to modify.

Although not all sheets need a quick update, a part of them do need it, and it is estimated to generate periodically all the sheets within 4 months, or less. Due the own characteristics of BTN25 and MTN 25, a tool able to customize our task and to implement common generalization operators was needed.

The general structure of the process arose:

- Designing a translation module from the model database to the final cartographic model, contemplating the possibility of changes in both models.
- Designing independent modules that can be improved without affecting the other modules.
- Avoiding, where possible, elimination of the features that come from BTN25 and, in any case, controlling the deleted features.
- Defining fixed global numerical parameters, or recalculated according to the geometric needs, of each module. With these parameters we can approximate roughly the current model MTN25.
- Identifying the features that must remain unchanged throughout the entire process, the features that could collapse, or be displaced or simplified.

2.2. Detailed strategy

Concerning the input information, apart from BTN25 data, it comes also from other different sources which are harmonized with BTN25 model (land use map, administrative boundaries, street networks and toponyms).

For detailed analysis of the processes the following items are considered:

- For road networks, fixing some elements (e.g., rivers) and classifying the networks according to their importance, for applying transformers and algorithms performing displacements.
- For areas, classifying them to determine which of them remain fixed, pushing other elements, and which can be moved or removed.
- For buildings, a zoning strategy has been developed that allows a detailed treatment according to a building density parameter. Three types of zones, depending on its density, have been introduced: low, medium or high. In each of these zones, the operators act differently.

- For symbols, a detailed hierarchy that allows collapsing, moving, or deleting features according to our current standards.
- For toponymy, developing algorithms that labels features, with names from database, within the cartographic rules for placement of toponyms.

3. Tool implementation in FME

Since the methodology described above requires a very specific data processing to fulfil its procedure, the idea of implementing our own tool designing our own algorithms was almost obligatory.

The software to implement our tool was selected considering the key aspects in our project:

- **high computing power**, due to the high number of geometries that are facing up the geometric calculations
- **modular programming,** to allow structuring the different process of the workflow,
- facilities in **algorithms customizing**,
- and, finally, the possibility of integrate all the processes in a **unique platform**.

According to this premises, FME®, a Safe Software tool belonging to the field of ETL tools (Extract-Transform-Load), was chosen to implement our methodology. Other national mapping agencies have used this software for similar tasks (van Altena et al, 2013), with very good results.

Then our automatic tool, running all the processes related with the different topics of map edition (linear elements, buildings or symbology), was created within FME environment. Due to the large number of map-sheets that the tool must deal with (more than 4100) a comprehensive concept of automation was required. Therefore the automatic execution has been considered in two senses: By one hand, it executes in chain all the linked processes without the need of any person triggering them in the meantime. And by the other hand, the tool calculates automatically the parameters required for the calculations depending on each context appearing on every zone.

3.1. Implementation Overview

FME implementation is based on different workspaces containing the transformers which carry out all the operations of the workflow. Thus a workspace has been designed for each topic related to map edition, in addition to a main workspace that executes them in chain.

Figure 2 shows as the workflow of the tool is structured in the different workspaces:

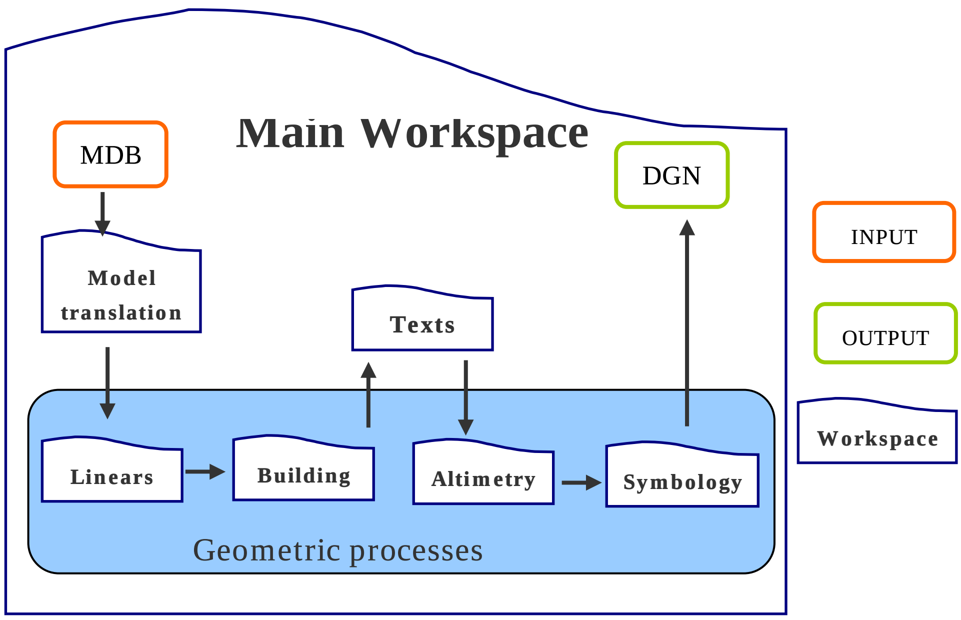

Figure 2: Structure of the workflow in workspaces

3.2. Detailed implementation

This section shows in more detail each of the processes contained in each workspace:

The **main workspace,** retrieves the input data (BTN in MDB format), executes the different workspaces performing the model translation and other geometrics operations and finally returns the resulting map (MTN in a DGN file).

The first workspace executed is the one related to the **Model Translation.** In this stage all the features of BTN are classified in elements of MTN25 according with its feature-type and its attributes. For this purpose, a mapping table between BTN and MTN25 elements was developed.

Once the model has been translated, the linear data are processed in the **Linears Workspace,** which carries out the following processes:

- Generalization of lines using Douglas algorithm.
- Selection of different linear features such as paths or fences, depending on their length and the density of these elements in the area.
- Axes unification of dual carriageways.
- Separation of linear elements.
- Roads segmentation in tunnels and bridges

Right after processing linear elements the **Workspace related to Buildings** starts running.

This is the more complex workspace of the tool due to the high interaction between buildings, not only with themselves but also with roads and other linear elements. This interaction implies that while some conflicts between buildings and roads are being solved, a chain effect is produced generating other new conflicts.

One of the possible solutions to this problem is a recursive loop solving the conflicts generated in the previous iteration. However the use of loops in the workflow have been refused due to the loss of control over what is happening in addition to the high consumption of time.

Thus, this problem has been faced through a very detailed classification of the possible conflicts between buildings and roads and also through the definition of strategies to apply to each one of these conflict cases (e.g., displacements, scaled, groupings, collapses).

This classification is mainly founded on the map-sheet zoning based on the density of buildings, and on the number of roads crossing them. Thus the tool generates regions surrounding built-up areas and classifies them in low, medium or high density. Figure 3 shows a map-sheet zoning example through a 'cloud-like' configuration.

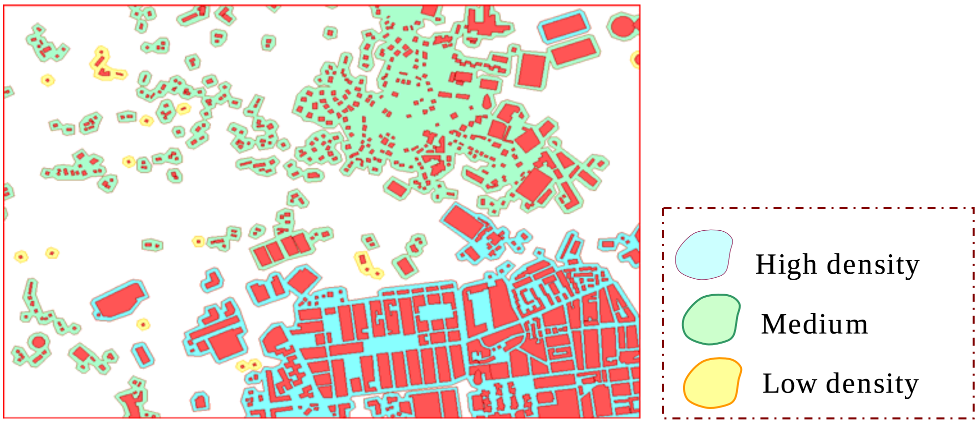

Figure 3: Classification in different density areas

Once the tool has carried out the classification, it applies the strategy defined for each one of these cases. Figure 4 shows the flow of actions according to each one of these strategies.

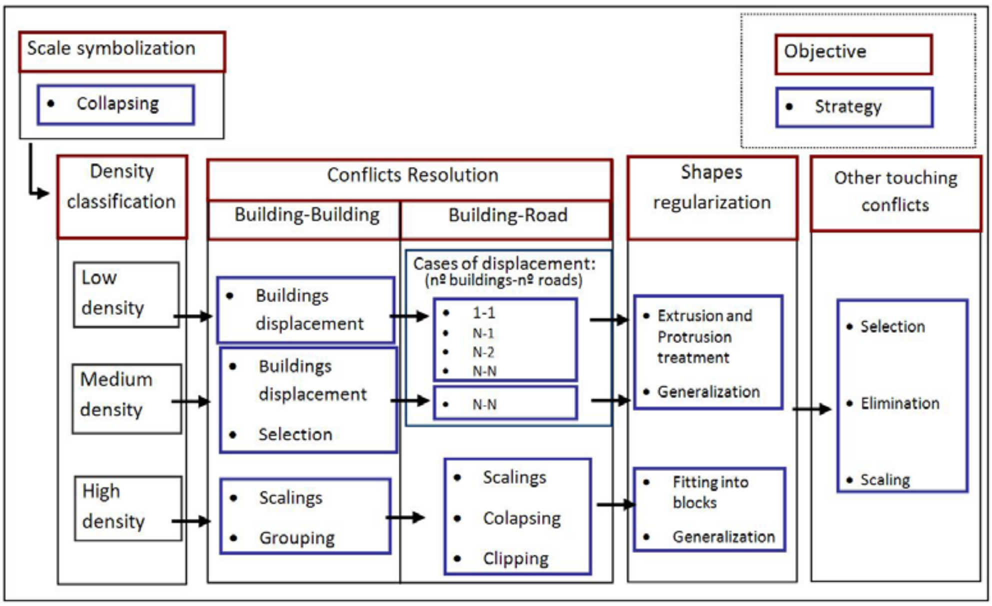

Figure 4: Strategies applied in each case for each objective

The next process which is executed corresponds to the **Altimetry workspace**. At the current time of the development, in this section the selection of level points is the only process considered, through which the more representative points of the terrain (such as hills, holes, mountain passes) are selected and the other ones are eliminated.

The next step is the **Text workspace** execution, in which there isn't any geometric operation with the BTN features, but a selection of texts and the study of its placement are carried out.

Finally, the **Symbology workspace** is executed to refine some aspects related to symbolization as e.g. surfaces filling with patterns, or the symbolization of some special symbols.

4. Results

At the moment, several zones representing the different singularities of the total country coverage have been processed in order to check the results and to validate our tool. The quality control is guaranteed by the editing phase of the results by the methods used in the current production process MTN25.

The results are examined by the more specialized personnel of our organization in map editing, allowing us to test the tool and to calibrate some of the fixed parameters used by the algorithms.

Although at the moment the tool is still being improved and calibrated, some satisfactory results have been already obtained, and in addition many of them have been used as a starting point in the traditional editing process.

Figure 5 shows the dynamics of generalization operators on buildings, with overlap between raw data (empty areas) and FME -Viewer output (coloured areas). In it some aspects such as shape regularization, displacements, selection, buffered road network and 'cloud-like' areas can be appreciated.

Figures 6 and 7 show some examples of the obtained results. On the left the raw BTN25 representation with FME-viewer is illustrated. On the right is the output of the automated process, with toponymy. The generalization produced in buildings and railway lines, and displacement, rescaling and groupings of buildings can be appreciated. Added external information from the network of streets in towns (called Cartociudad) can also be seen in the figures.

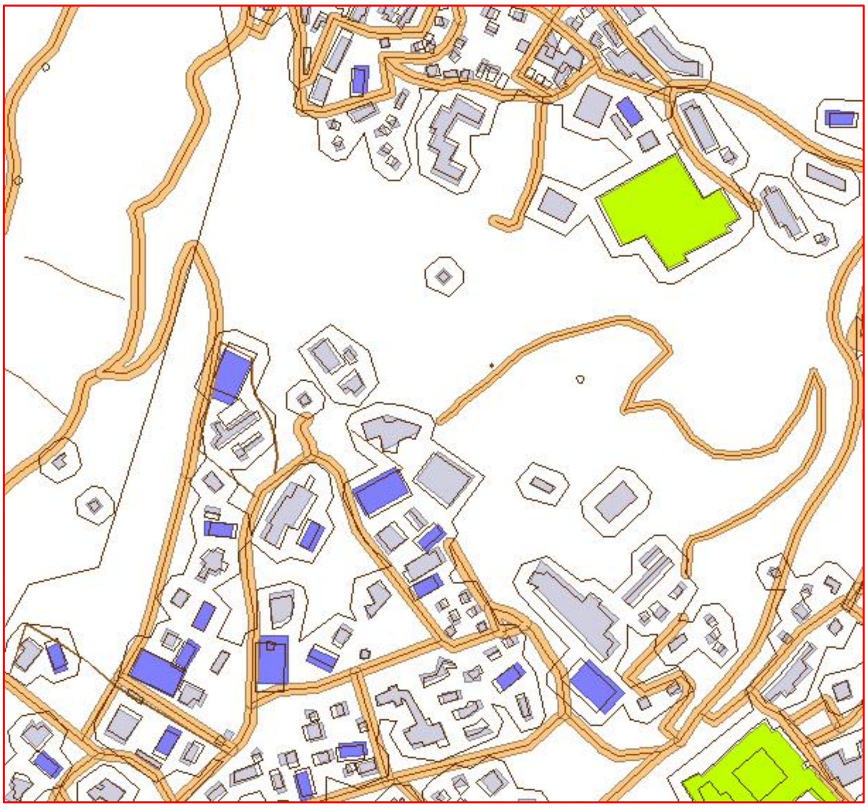

Figure 5: Dynamics of generalization operators in FME-Viewer output

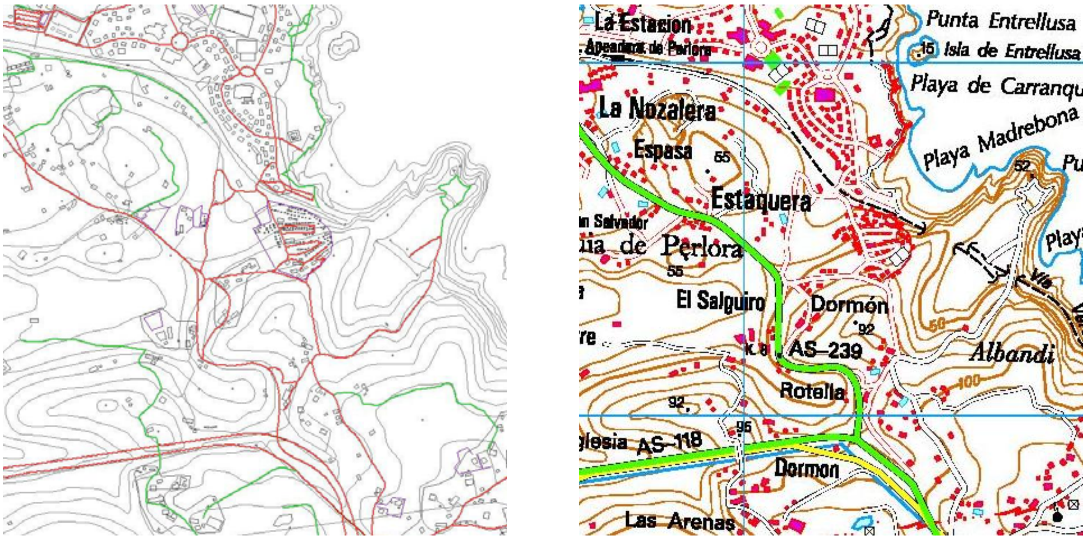

Figure 6: Results in low and medium density areas (left: Database raw data; right: automated process output)

Figure 7: Results in a high density area (left: Database raw data; right: automated process output)

5. Concluding remarks

Currently, the automated map is being implemented and some problems are being detected, therefore the tool is being improved. Obtaining automated map represents a breakthrough for two reasons. The first, because it accelerates the process of obtaining the map from BTN25, and provides user recently updated mapping information. And second, it allows us to redirect efforts, currently assigned to editing processes, to BTN25 continuous updating and automation processes.

In the future, we hope to apply these processes to the generalization of our basic cartography (MTN25) to other scales that have been assigned to IGN (1: 50k or 1: 200k). In line with other NMAs, we hope to implement automated generalization within our production lines (Duchêne et al, 2014) and to design a multiple representation database (MRDB) (Sarjakoski, 2007) that allows us to manage all our topographic databases and the cartographic products that are extracted from them, by model and cartographic generalization. These expectations are based on experience gained in the development of the FME-tools explained in this article, and on experience in national topographic map production for many years by IGN cartographers.

Acknowledgement

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